PATENT SPECIFICATION

716,761

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COMPLETE SPECIFICATION

Improvements in or relating to Drill Assemblies

We, STANDARD OIL DEVELOPMENT COMPANY, a Corporation duly organised and existing under the laws of the State of Delaware, United States of America, having an office at Elizabeth, New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns a novel and improved form of drill assembly provided with a retractable drill bit.

It has long been appreciated that a desirable form of drill bit for use in oil exploration would be a bit which could be placed in cutting position and could be periodically retracted and returned to the surface of the earth without necessitating removal of the drill string from the borehole. Such a bit is particularly attractive in minimizing the time and expense of pulling a drill string from a well bore and of replacing the string whenever necessary to replace or recondition a drill bit. There have been a variety of suggestions as to bits of this general character. However, the problems involved in providing an entirely suitable retractable drill bit are sufficiently difficult so that there has been a demand for an improved type of retractable drill bit.

The present invention is concerned with this objective and provides in a drill assembly a desirable form of expansible and retractable bit overcoming many of the disadvantages of presently known drill bits of this character. For example, as will be brought out, the drill assembly of this invention is used in conjunction with a drill collar which does not require internal slots or grooves which would be subject to disabling plugging by drill cuttings and sediment. Again, for example, provision is made to transfer torsion from the drill stem to the cutters without necessitating use of a slotted drill collar or the like, imposing undesired stress limitations.

In accordance with this invention there is provided a drill assembly comprising in combination: a tubular drill collar having one or more circumferential grooves on the interior surface thereof and a retractable drill bit having a cylindrical element fitting within said drill collar in sliding relationship therewith including at least two longitudinal slots, at least two drill cutter supports positioned in said longitudinal slots in sliding relationship between the cylindrical element and the drill collar, a drill cutter element suspended from each of said cutter supports, latching means pivotally fixed to each of said cutter supports adapted to extend into said, or one of said, circumferential grooves to limit downward movement of each support with respect to the drill collar, and latching means pivotally fixed to said cylindrical element adapted to extend into said, or a second of said, circumferential grooves to limit upward movement of said cylindrical element with respect to the drill collar.

The appended drawings illustrate a preferred embodiment of the drill assembly of this invention illustrating as well a number of desirable features which may be included in the drill assembly. It should be observed that for simplicity the drawings have been prepared to illustrate a retractable hard formation drill bit having two cone cutters. In actuality it is preferred to employ three cone cutters but the principles of operation can better be understood by considering a drill bit employing two cone cutters.

Figure 1 of the drawings illustrates the drill assembly of this invention in elevational cross-sectional detail, showing the drill bit in an extended and locked drilling position in the drill collar;

Figure 2 is a side view of the drill bit taken at right angles to Figure 1 and showing the drill collar in cross section;

Figure 3 is a cross-sectional elevational view of the lower portion of the drill bit in retracted position;

Figure 4 is a cross-section view of the apparatus of Figure 2 along the line IV—IV;

Figure 5 is a cross-section of Figure 1 along the line V—V;

Figure 6 is a detailed cross-sectional elevational view of a preferred arrangement of the upper portion of the drill.

Referring now to Figure 1, a drill collar

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Price 4s 6d Price 25p

is designated by the numeral 1 which is designed to co-operate with the drill bit illustrated. Drill collar 1 may be fixed to a conventional casing or drill string by means of suitable threaded coupling. The drill collar will have substantially the same internal diameter as the drill string through which and with which the drill is to be operated. Preferably, however, the external diameter of the drill collar 1 is somewhat enlarged so as to provide a thicker wall than that of the drill string The drill collar simply comprises a tubular member of substantial wall thickness to provide the necessary strength required to drive the drill bit fixed within this drill collar. The lower and inner termination of the drill collar is provided with an outwardly and downwardly opening enlargement. This serves to provide a downwardly and outwardly open taper 3 against which the drill cutter support members may be wedged as will be described. Two circumferential grooves 4 and 5 are machined in the drill collar to accommodate latching dogs positioned on the drill bit. As described therefore, the drill collar simply comprises a tubular member having annular grooves 4 and 5 and provided with an outwardly flared opening 3. The drill collar is notable for the absence of any longitudinal slots or grooves and by its simplicity of construction.

Fitting within the drill collar 1 is a retractable drill bit essentially comprising three elements. An inner mandrel 8 constitutes the central portion of the drill bit having a diameter somewhat less than the internal diameter of the drill collar. The mandrel 8 is provded with two diametrically opposed longitudinal grooves extending substantially the length of the mandrel. These grooves are best shown in Figures 2 and 4 and are identified by numerals 11 and 12. Fitting within the grooves 11 and 12 are the two remaining principal elements of the drill bit consisting of slidable sections 13 and 14. As will be described, each of the slidable sections 13 and 14 is free to slide upwardly or downwardly with respect to mandrel 8 in the groove provided to the extent permitted by the latching dogs and mating shoulders provided on sliding sections 13 and 14 and mandrel 8. The grooves 11 and 12 may dovetail with each sliding section to hold these sections in the grooves or slots and pins may be provided for this purpose.

Each of the sliding sections 13 and 14 serve as supporting and guiding members for a cone cutter 10 which is suspended from each of them. The cone cutters 10 of conventional design and the mounts therefor may be suspended from the guide members by the straps or suspension arms 15. A pivot pin 16 passing through the lower termination of each suspension arm and passing through each cone cutter mount serves to permit pivotal movement of the cone cutter mounts within the drill collar. Downward movement of each guide member 13 or 14, with respect to the drill collar is limited by latchings dogs 6 which are pivotally fixed to each sliding element and are arranged to bear against the shoulder of the annular groove 5 machined in the drill collar. Each of the latching dogs 6 is urged outwardly into latching position by means of leaf springs 7. The latching dogs are provided with inward extensions, shaped to mate with a recess 20 or 21 cut in the slotted portions of mandrel 8. The extensions of the latching dogs may thus fit within the recesses 20 and 21 when the dogs are forced into these recesses, permitting the latching dogs to lie flush with the periphery of the mandrel.

The lower portion of guide member 13 has a cutaway inner portion so as to provide a shoulder 23 positioned some distance below latching dog 6. The lower termination of slot 11 of mandrel 8 is built out somewhat so as to provide a shoulder 24 adjacent the lower portion of the mandrel. As will be described, shoulder 24 is adapted to meet shoulder 23 so as to limit downward movement of guide member 13 with respect to the mandrel 8. Guide member 14 is similarly provided with a shoulder 25, which, however is positioned at a different distance below latching dog 6 fixed to guide member. Again, shoulder 25 is adapted to bear on a shoulder 26 provided in the slot 12 of the mandrel 8.

The lowermost portion of each guide slot 11 and 12 of the mandrel is cut away more deeply to form a bed in the slot which is tapered inwardly. When the drill is in the position shown in Figure 1, the tapered shanks of the cone cutter supports fit against the taper of the slots referred to. The wedge shaped shank of each cone cutter support therefore wedges tightly between the drill collar 1 and the mandrel 8 when weight is placed on the cone cutters.

In order to maintain the mandrel in a locked downward position to maintain the cone cutters in the positions illustrated in Figure 1 when weight is applied to them, latching dogs 30 are provided at the upper end of the mandrel 8. These latching dogs are pivoted in slots of the mandrel and are normally urged outwardly by leaf springs 31 as better shown in Figure 6. The latching dogs will thus be forced into the annular groove 4 of the drill collar when registered therewith so as to lock the mandrel 8 against upward movement with respect to drill collar 1. It is apparent that when the mandrel has been forced downwardly sufficiently far to permit the latching dogs 30 to spring out-

wardly into the latching position illustrated, the cone cutter support will be locked into the expanded position shown in Figures 1 and 2 so as to permit drilling.

The inner portion of the latching dogs 30 are provided with recesses 36 which may close over the spearhead 37 of a retrieving tool when the latching dogs 30 are forced inwardly.

With this description of the general arrangement of the elements of the retractable drill assembly illustrated, the operation of this drill bit may now be understood. Assuming that the drill bit is in the extended drilling position illustrated in Figure 1, operation of the elements will be described as the drill bit is forced into retracted position for removal from the drill string.

In order to retract the drill bit of Figure 1, a retrieving tool having a suitable spearhead 37 is lowered into the drill string by means of a wire line cable. As will be brought out in connection with Figure 7 of the drawings, the retrieving tool in addition to the spearhead 37 must have tapered surfaces of a nature to force the latching dogs 30 inwardly over the spearhead to permit the latches 30 to pass upwardly into the drill string while preventing release of the spearhead from the recesses 36 provided in the latching dogs. When the latches have been forced to this position, spearhead 37 may be pulled upwardly through the drill collar and drill string together with the drill bit when retracted.

In a first step of the retraction operation, mandrel 8 will be pulled upwardly while guide members 13 and 14 remain in a fixed position with respect to the drill collar. Thus on retraction of latching dogs 30 the mandrel is free to slide upwardly. However, upward movement of the guide members 13 and 14 supporting the cone cutters is impossible during this step of the operation. This is true for the reason that latching dogs 6 associated with each guide member are essentially wedged in the annular groove of the drill collar so as to prevent upward movement of each guide member until latching dogs 6 may be forced into retracted position.

Consequently on upward movement of the spearhead, mandrel 8 will be pulled upwardly until recess 21 provided in the mandrel registers with latching dog 6 pivotally fixed to guide member 14. Shoulder 26 provided on mandrel 8 is positioned to contact shoulder 25 of guide member 14 when recess 21 registers with latching dog 6. Consequently when the mandrel has been pulled upwardly to this position, shoulder 26 bearing against shoulder 25 will force guide member 14 to move upwardly through the drill collar with the mandrel 8. This upward movement of guide member 14 will force the latching dog 6 associated therewith into the recess 21 into the position particularly illustrated in Figure 3. The cone cutter 10 supported by guide member 14 will be free to swing inwardly into the drill collar for upward movement therethrough, again as illustrated in Figure 3.

It will be observed that during this phase of the operation, that is when the first guide member and first cone cutter is pulled upwardly into the drill collar, the second cone cutter and the guide member associated therewith is still maintained in a locked position. Thus the latching dog 6 associated with guide member 13 is wedged in annular groove 5 of the drill collar, preventing movement of guide member 13 with respect to the drill collar until the recess 20 in mandrel 8 registers with this latching dog. When the mandrel 8 carrying the first guide member 14 is pulled upwardly sufficiently for recess 20 to register with latching dog 6 of guide member 13, shoulder 24 of the mandrel will bear against shoulder 23 of guide member 13. Consequently in the course of upward movement of mandrel 8, when this occurs, guide member 13 will be pulled upwardly through the drill string. Latching dog 6 mounted on guide member 13 will be forced into the recess 20 as illustrated in Figure 3. The cone cutter 10 supported from guide member 13 may then swing inwardly into the drill collar at a position below the first cone cutter. The entire drill bit may then be pulled upwardly through the drill string with all elements thereof in the retracted position shown in Figure 3.

The manner in which the retractable drill can be lowered through the drill string to assume drilling position will now be described. It is assumed that the elements of the retractable drill are placed in the arrangement shown in Figure 3; in addition latching dogs 30 are closed over the spearhead of a lowering tool and are held in this position by the inner surface of the drill string and drill collar. The drill is lowered through the drill string into the drill collar without change in the relative position of the elements until latching dog 6 associated with guide member 13, reaches the lower annular groove 5 provided in the drill collar. When this occurs, latching dog 6 expands outwardly so as to prevent further downward movement of guide member 13. Mandrel 8 will continue to move downwardly together with the second guide member 14. When lowered sufficiently, latching dog 6 associated with guide member 14 will similarly expand to latching position in the annular groove 5 of the drill collar to prevent further downward movement of guide member 14. At this instant in the operational sequence, the two

cone cutters associated with the guide members 13 and 14 will be at the proper horizontal position with respect to drill collar 1. However, the cone cutter supports will be hanging loosely within the lower portion of the drill collar. Mandrel 8 is, therefore, forced downwardly, sliding with respect to guide members 13 and 14, until the tapered surfaces provided on the lower termination of the mandrel wedge the cone cutter supports against the drill collar. This occurs when the mandrel 8 has been lowered to the position shown in Figure 1 at which position upper latching dogs 30 are enabled to extend into latching position in the upper circumferential groove 4 provided in the drill collar. Extension of these upper latching dogs serves to lock the entire drill in the position shown in Figure 1 and also serves to release spearhead 37 permitting removal of the lowering tool.

On then lowering the drill string sufficiently to cause the cone cutters to contact the bottom of the borehole, each cone cutter support will further be wedged between the mandrel 8 and the drill collar 1 to permit drilling.

While not essential, as shown in Figure 5, an extension or lug 38 may be positioned in the upper circumferential groove 4 of the drill collar 1. This lug will limit rotational movement of the latches 30 with respect to the drill collar. This serves to prevent rotation of all the drill elements with respect to the drill collar 1. This will prevent any rotational slipping prior to the time the cone cutter supports are firmly wedged between the mandrel and the collar as described. It should be observed, however, that substantially no rotational torque is transmitted through lug 38 during normal drilling operations since the torque is transmitted directly through the drill collar to the wedged cone cutter supports.

A central channel 39 is provided in the centre of mandrel 8 associated with ports 40 adjacent the cone cutters. Drilling mud may be forced through the drill string and through these ports to lubricate the cutters and flush the cuttings out of the bottom of the hole during drilling.

As formerly indicated, while the invention has been described with reference to a drill bit employing two cone cutters, it is particularly contemplated that the drill bit should employ 3 cone cutters. Employing the principles described, this is readily achieved by positioning three equally spaced longitudinal grooves in mandrel 8 in place of the two described. An additional recess is placed on mandrel 8 corresponding to recesses 20 and 21 of Figure 1. This additional recess will again be at a different level from recesses 20 and 21. Consequently these provisions will enable a third drill cone to be suspended below the other two in the same manner described. As a practical observation it may be noted that drill cones of larger sizes may be employed when three rather than two cone cutters are used. This is possible by virtue of the fact that the conical shape of these cutters acting with the 120° spacing around the mandrel permits utilization of somewhat larger cone cutters. It should be observed that if desired, latches 30 may be fixed to mandrel 8 at a lower level in a manner to register with annular groove 5. By providing a shoulder in this groove for latches 30 to act against, groove 4 may be dispensed with.

The drill assembly heretofore described is preferably provided with additional apparatus features. These are illustrated in Figure 6. Figure 6 illustrates a preferred embodiment of the drill bit showing only the portion of the drill bit above the latching dogs 6. In all other respects the drill bit will have the construction which has been described. As illustrated in Figure 6, the mandrel 8 is provided with a separate section 50 maintained in telescopic sliding relation with the upward termination of mandrel 8 which is cut to have a reduced external diameter. Sliding movement of the upper portion 50 with respect to the lower portion 8 is then possible. One or more pins 51 fastened in the tubular member 50 extend into slots 52 positioned in the upper portion of mandrel 8. Slots 52 have sufficient longitudinal length, extending upwardly and downwardly, to permit limited movement of element 50 with respect to mandrel 8. A rubber sleeve 53 is positioned on a shoulder of mandrel 8 just below the lower termination of element 50. This rubber sleeve 53 preferably has an upward and outwardly opening taper at its upper portion to accommodate the downward and inward tapering termination of member 50. Thus when member 50 is forced downwardly so as to slide with respect to mandrel 8, the tapered termination of member 50 will force the rubber sleeve 53 firmly against drill collar 1. This serves to provide a circumferential seal between the drilling apparatus and the drill collar. The purpose is to prevent by-passing of cutting fluid between the drill collar and the drill bit. All cutting fluid is thus forced downwardly through channel 39 of the mandrel to be supplied to the cone cutters.

Another preferred feature illustrated in Figure 6 concerns the arrangement of latching dogs 30. As shown in Figure 6, the inner portion of each latching dog 30 is provided with teeth to mate with teeth positioned on the upper termination of mandrel 8. This "wicker" arrangement, identified by

numeral 54, provides an important function. As a practical detail of construction it is undesirable to require that the drill bit be machined with such accuracy that latch 30 will just reach operational position when the cone cutter supports are forced into the tightest locked position on lowering of mandrel 8. The wicker referred to serves to eliminate necessity for construction of this precision. Thus the latch 30 in the embodiment of Figure 6 is pivotally supported on element 50 which in turn fits on mandrel 8, so that the latch 30 will normally extend somewhat above the recess 4 in which it is intended to seat when the drill bit has been lowered to drilling position. Consequently, on applying downward force on the spearhead employed to position the drill bit in the drill collar, element 50 may be forced downwardly sufficiently to cause the latch 30 to move the remaining distance necessary to seat in the annular groove 4. This will serve to forcibly extend the packing element or rubber sleeve 53 into sealing position. Once the latches 30 have been forced downwardly so as to enter the groove 4, as illustrated in Figure 6, then the teeth of wicker 54 will serve to lock the mandrel in the indicated position when the insertion force applied by the spearhead is removed.

What we claim is:—

1. A drill assembly comprising in combination: a tubular drill collar having one or more circumferential grooves on the interior surface thereof and a retractable drill bit having a cylindrical element fitting within said drill collar in sliding relationship therewith including at least two longitudinal slots, at least two drill cutter supports positioned in said longitudinal slots in sliding relationship between the cylindrical element and the drill collar, a drill cutter element suspended from each of said cutter supports, latching means pivotally fixed to each of said cutter supports adapted to extend into said, or one of said, circumferential grooves to limit downward movement of each support with respect to the drill collar, and latching means pivotally fixed to said cylindrical element adapted to extend into said, or a second of said, circumferential grooves to limit upward movement of said cylindrical element with respect to the drill collar.

2. A drill assembly according to Claim 1 in which the lower termination of the said cylindrical element bears against the said drill cutter elements in the said latched position wedging the drill elements against the lower termination of the drill collar.

3. A drill assembly according to Claim 2 in which the portion of the cylindrical element bearing against the drill cutter elements is tapered.

4. A drill assembly according to Claim 1 in which the inner and lower termination of the drill collar is tapered outwardly.

5. A drill assembly according to Claim 1 in which each of the said cutter supports includes a shoulder and in which the said cylindrical element includes a shoulder adapted to mate with the said shoulders of the cutter supports.

6. A drill assembly according to Claim 1 in which the said latching means associated with each cutter support includes an inward extension and in which the said cylindrical member includes a recess for each of said extensions.

7. A drill assembly according to Claim 1 in which three cutting elements are employed.

8. A retractable drill substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

9. A drill assembly substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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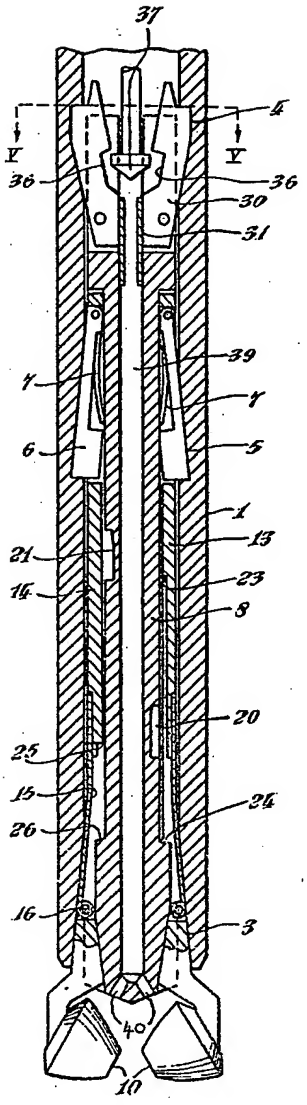


Fig. 1.

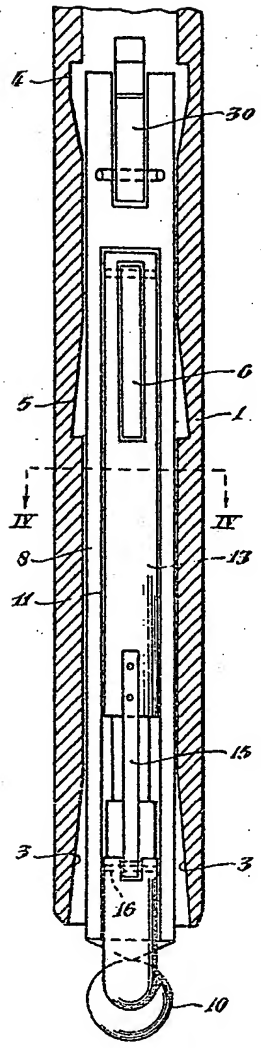
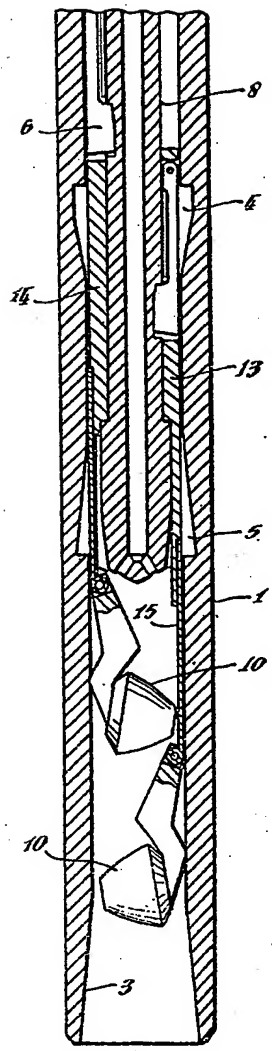


Fig. 2.



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3 SHEETS

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SHEETS 1, 2 & 3

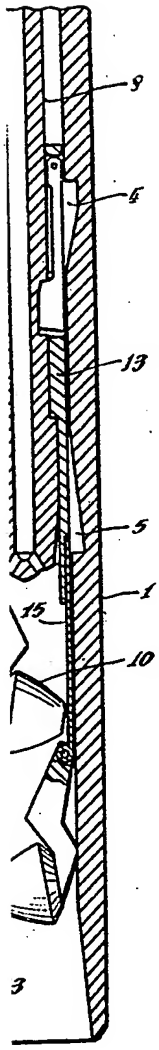

Fig. 3.

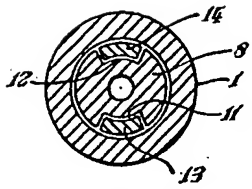

Fig. 4.

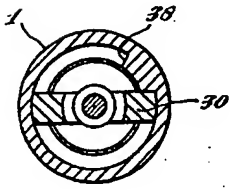

Fig. 5.

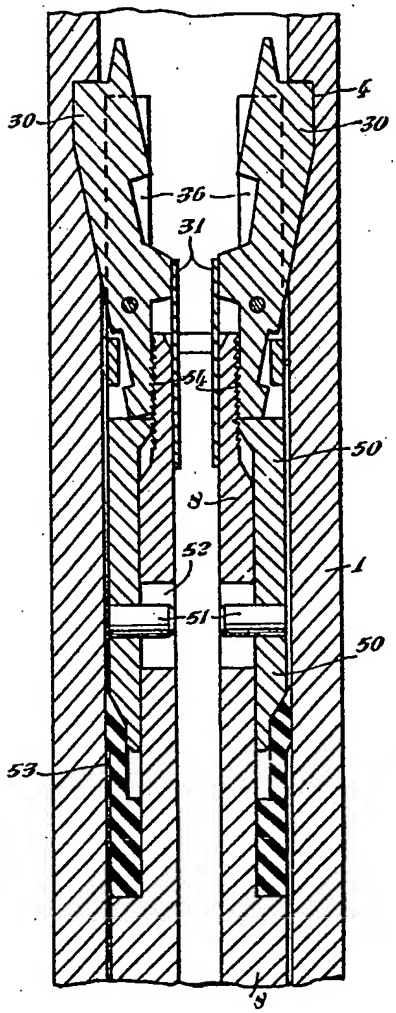

Fig. 6.

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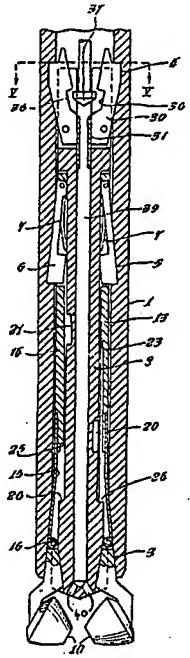

Fig. 1.

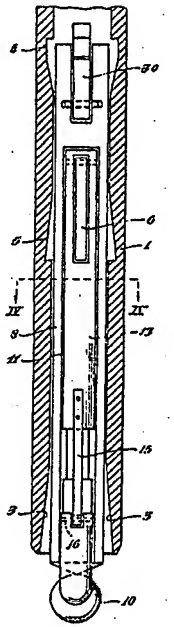

Fig. 2.

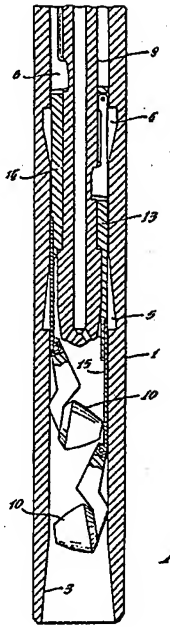

Fig. 3.

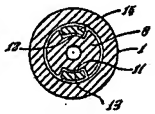

Fig. 4.

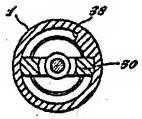

Fig. 5.

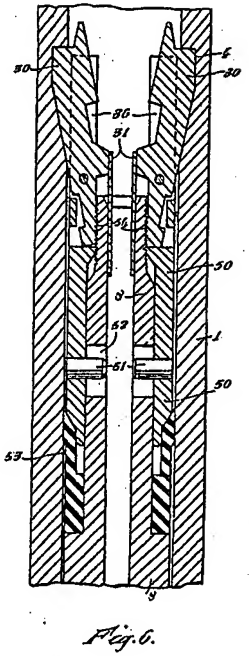

Fig. 6.